Measure Identification Report

California Outdoor Lighting Standards

March 18, 2002

Prepared for:

California Energy Commission

Prepared by:

142 Minna Street
San Francisco
California 94105
(415) 957 1977 Voice
(415) 957 1381 Fax
www.eley.com

Subcontractors:

Benya Lighting Design
Heschong Mahone Group
Clanton & Associates, Inc.
RLW Analytics

Overview

Measures

This document describes a project underway by the California Energy Commission to develop standards to regulate the energy use of outdoor lighting in California. The project will address outdoor lighting in both the public and private sector. Measures are proposed by the CEC and the contractor team for the following outdoor lighting applications.

- Unconditioned Buildings
- Parking Lot Lighting
- Building Grounds Lighting
- Building Entrance and Exit Lighting
- Building Facades
- Lighting Under Exterior Canopies
- Outdoor Sales Lighting
- Billboard and Outdoor Signage Lighting
- Public Right of Way Lighting

Benefits

Outdoor lighting consumes a great deal of electricity and can be a significant contribution to peak electricity demand, especially when it is improperly controlled. Through legislation adopted in 2001 the Commission has been directed to establish energy efficiency standards for outdoor lighting to save energy and reduce electricity peak demand.

It is important to note that poorly designed outdoor lighting can cause environmental impacts resulting in community and social problems, such as light trespass and light pollution.

In adopting energy efficiency standards for outdoor lighting, the Commission will consider the implications of energy efficiency improvements on these issues. The Commission will consider outdoor lighting improvements that cost-effectively save energy and/or reduce peak demand, and also either reduce or avoid increasing light trespass and light pollution.

The *Advanced Lighting Guidelines*[1] have more information on light trespass (§3.2.4) and light pollution (§3.2.5). The *Advanced Lighting Guidelines* also contain other information pertinent to this project, including §4.3.1, Light Distribution: Advanced Guideline-Light Pollution and Light Trespass; §4.4.2 Lighting Analysis Tools-Exterior Lighting Calculations; §5.9, Exterior-Gas Stations; and §7.6, Outdoor Luminaires.

Project Goal

The goal of the project is to conserve energy and reduce electricity peak demand by adopting cost effective energy efficiency standards for outdoor lighting consistent with public health and safety.

In adopting cost effective energy efficiency standards for outdoor lighting, the Commission anticipates that these Standards will also improve the quality of outdoor lighting. Also, to the extent that these measures are cost effective, the Commission expects that the Standards may reduce the impacts of poor outdoor lighting

[1] The *Advanced Lighting Guidelines* is a publication sponsored by the California Energy Commission and others. The document is in its third edition and is available from the www.NewBuildings.org and from other sources.

systems, such as light trespass, excessive illumination, poor uniformity, glare, and poor visibility. In addition, the Commission anticipates that persons complying with the Standards will learn about effective outdoor lighting technologies and techniques, through guidance information that the project produces to aid compliance.

The Legislative Mandate

In response to the California energy crisis, the California Legislature passed and Governor Davis signed Senate Bill 5X (Statutes of 2001), which requires the California Energy Commission to adopt energy efficiency standards for outdoor lighting. SB 5X added the following section to the Public Resources Code:

> *25402.5 (3) (c) The Commission shall adopt efficiency standards for outdoor lighting. The standards shall be technologically feasible and cost-effective. As used in this subdivision, "outdoor lighting" refers to all electrical lighting that is not subject to standards adopted pursuant to Section 25402, and includes, but is not limited to, street lights, traffic lights, parking lot lighting, and billboard lighting. The Commission shall consult with the Department of Transportation (CALTRANS) to ensure that outdoor lighting standards that affect CALTRANS are compatible with the department's policies and standards for safety and illumination levels on state highways.*

Through this project, the Commission intends to develop and adopt lighting standards for all outdoor lighting applications, including all non-conditioned areas that are not already subject to existing California Standards. Such lighting includes but is not limited to lighting in unconditioned buildings, lighting that is mounted on the exterior of buildings, lighting that is exterior to buildings but controlled from the electrical panel of the building, and lighting that is not controlled from a building. Examples of outdoor lighting include lighting in unconditioned warehouses and other unconditioned building spaces, lighting for parking lots, signage and advertising, car lots, and service stations, street and highway lighting and other outdoor lighting systems.

Some outdoor lighting may currently be regulated in the California Electrical Code, the California Fire Code, or in other rules of state and local government agencies. The Commission intends to develop standards that may be appropriately adopted in the California Energy Code (Title 24, Part 6) or in other Parts of Title 24 or other rules adopted by state or local government agencies.

The Commission has targeted July 1, 2003 for adoption of these new California Outdoor Lighting Standards. Those portions of these Standards that are adopted in Title 24 are expected to go into effect in conjunction with the 2005 California Building Code, expected to become mandatory in 2005. Between the 2003 adoption date and the 2005 effective date, the Commission anticipates that the California utilities will focus Public Goods Charge-funded programs on providing a transition process for early, voluntary compliance with the new Standards.

Existing Outdoor Lighting Standards

California Standards

California has had energy efficiency standards for new buildings since 1978, but these standards apply to exterior lighting in only a limited way. For nonresidential and high-rise residential buildings and hotels/motels, §130 (c) of the Standards requires that lamps rated greater than 100 watts have an efficacy of at least 60 lumens per watt, but there are a number of exceptions to the requirement. §130 (f) requires that all permanently installed exterior lighting powered by the building electrical service be controlled by either a photocell or astronomical time switch. The California Standards currently only apply when this exterior lighting is connected to the electric system of a building that is covered by the Standards. The current Standards do not apply to the types of outdoor lighting covered by the new legislation.

For nonresidential and high-rise residential buildings and hotels/motels, the Building Energy Efficiency Standards limit the lighting power that can be installed in interior spaces, but the limits only apply to spaces that are conditioned or semiconditioned as defined by the Standards. The Standards do not apply to unconditioned warehouses, unconditioned manufacturing facilities or other unconditioned spaces. Essentially, the current Standards treat these unconditioned interior spaces as outdoor spaces, and exempt them from the lighting power requirements. This project will develop standards for unconditioned spaces, which are presently unregulated.

For low-rise residential buildings, the current Standards address exterior lighting only as an alternative to efficacy requirements for bathrooms in § 150(k)2., Alternative B. A high efficacy luminaire need not be installed in a bathroom if all luminaires providing outdoor lighting have lamps with an efficacy of 40 lumens per watt or higher or are equipped with a motion sensor. This project will consider other Standards requirements for outdoor lighting in low-rise residential buildings.

Other Standards

ASHRAE/IESNA Standard 90.1-1989 has been adopted for federal buildings and as the energy efficiency standard in many states. This standard has lighting power requirements for a number of outdoor lighting applications, including: building entrances and exits, loading areas, exterior building surfaces, outdoor storage areas, driveways, walkways, parking lots and parking garages. This standard also requires that either photocells or time clocks control outdoor lighting applications (similar to California's Standards). See Appendix A for more information.

Proposed Measures

The following sections describe the outdoor lighting measures being proposed by the CEC and its contractors. Each of these proposed measures are developed in a consistent manner using a standard template.

Measure 1 – Unconditioned Buildings (CEC)

Proposer

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Researcher
Larry Ayers, LC
Eley Associates
142 Minna St.
San Francisco, CA 94105

Description

Expand the scope of the Title 24 building energy efficiency standards to include requirements for unconditioned spaces, which are currently not regulated. The requirements will include prescriptive lighting power density requirements and mandatory lighting control requirements.

Benefits

This measure will save energy, and therefore user costs, in buildings that do not now need to comply with Title 24.

Environmental Impact

This proposed measure will have no negative environmental impact.

Enforcement Mechanism

The proposed standard would be implemented in the Title 24 building energy efficiency standards. Changes to Title 20 are not anticipated, nor does this proposed standard incorporate a model standard or state legislation. The proposed requirements would be implemented both as mandatory measures (controls) and prescriptive requirements (limits on lighting power density). The regulatory approach for lighting power would be identical to that currently used for interior lighting power, e.g. Watts per square foot limits will be developed for various complete buildings and area categories. We do not anticipate the tailored method applying to unconditioned spaces.

Regulatory Approaches

Lighting Power Density	Prescriptive requirements would be limits on Lighting Power Density (LPD, Watts per square foot). These would be similar to those already in Title 24 for conditioned spaces.
Lighting Controls	Mandatory requirements would be lighting controls for unconditioned spaces as defined in Title 24 for conditioned spaces. For example, automatic shutoff controls would be required.

Considerations for Proposed Lighting Technologies

No new lighting technologies would be required for this measure.

Performance Verification

LPD as a prescriptive requirement does not need any commissioning or performance verification. Simply installing specified equipment as designed to meet the regulation will provide the anticipated performance and energy savings.

Mandated controls will usually require commissioning. For example, an automatic time switch will likely require programming to optimize lighting system operation. Failure to commission such a control may leave significant periods when lighting systems are unnecessarily energized, thereby wasting energy and decreasing component life. Improper commissioning may also leave a lighting system off when it is actually needed, thereby encouraging the user to override the control on a regular or permanent basis. Similarly, an occupant sensor installed to turn off unused lighting when a space remains unoccupied for over 30 minutes will probably need commissioning or performance verification to ensure proper detection coverage.

Technical Feasibility

This measure is completely technically feasible, with no change in existing lighting methods.

Cost Effectiveness

The proposed measures are both mandatory measures and prescriptive requirements and they must be shown to be cost effective for both area category and whole building. The approach for showing cost effectiveness of the lighting power density requirements will be the same as used for interior lighting applications. This approach involves developing a lighting model for each application and demonstrating through the model that the recommended lighting power density is justified. The models will include assumptions on target illuminance, space characteristics such as geometry and reflectances, efficacy of lighting sources and efficiency of luminaires. The approach is to show that each assumption used to justify the LPD is life cycle cost effective or reasonable for the lighting applications.

Title 24 documentation already includes a number of models that apply to unconditioned buildings.

Complete building models include:				
general highbay	general lowbay	commercial storage	industrial storage	warehouse
Area category models include:				
auto repair	industrial highbay	industrial lowbay	industrial precision	lockers
Mall	mechanical room	stairs	Storage	warehouse

ASHRAE/IESNA 90.1-1999 also includes some building and space models that may apply to unconditioned buildings.

Whole Building categories include:		
automotive facility	manufacturing	museum
parking garage	warehouse	workshop

Space Type categories include:			
active storage	atrium	electrical/mechanical	equipment room
general service/repair	general highbay	general lowbay	inactive storage
material warehouse	parking area, attendant	parking area, pedestrian	stairway
workshop			

The approach for showing that controls are cost effective is different. In this case, controls reduce the hours of lighting operation or reduce power through the control of multiple levels of illumination. The approach for controls will be to estimate the initial cost of the control and to then determine (in the case of lighting hours reductions), how many hours must be reduced in order for the control to be cost effective.

Compliance Documentation

All current compliance methods can be used as in existing Title 24, with the same effect.

Bibliography and Other Research

Title 24 Building Energy Efficiency Standards contain the mandatory and prescriptive measures for conditioned buildings that this measure proposes for unconditioned buildings. Supporting Title 24 are a number of complete building and area category models that are also applicable to unconditioned buildings. In addition, the cost effectiveness support for title 24 will also support this proposed measure.

ASHRAE/IESNA 90.1-1999 includes a number of building models, such as parking garages that can support these proposed measures.

The California Electrical Code and California Fire Code contain safety-related regulations. The proposed measures should comply with these regulations.

Measure 2 – Parking Lot Lighting (CEC)

Proposer

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Researcher
Nancy Clanton, PE, IALD, President
Clanton & Associates, Inc.
4699 Nautilus Court South, Suite 102
Boulder, CO 80301

Description

We propose to develop parking lot lighting power density limits to include in the Title 24 building energy efficiency standards. These will apply to all types of uncovered parking lots regardless of size or location. The Commission plans to determine the most appropriate method for computing parking lot area to include in lighting power allowance calculations.

Depending on the final analysis of the Energy Commission, the maximum lighting power densities may vary according to one of four environmental zones defined below in Background Information on Outdoor Lighting Environmental Zones and Curfew. The maximum lighting levels per zone will be established according to recommendations from Illuminating Engineering Society of North America (IESNA). These may be based on the “Evaluation of Task Adaptation Luminance” (ETAL) procedure. Refer to" Background Information on Evaluation of Task Adaptation Luminance" below.

The Commission will consider the need for lighting controls such as photocell and astronomical time clocks. Lighting controls may be required to turn off some or all lighting during curfew hours. Motion sensors may also be required to turn off or reduce lighting power (bi-level lighting control) during curfews hours or when the lights are not needed.

Benefits

Energy savings and peak demand reduction are major benefits of the proposed parking lot lighting standard. Other benefits include reduced light trespass and pollution. The proposed standard will not affect safety and security, since reduced glare will increase visibility.

Environmental Impact

The proposed measure will have no negative environmental impact. The proposed measure will have only positive impacts including reducing light pollution and light trespass.

Enforcement Mechanism

The proposed measure will be implemented as part of the Title 24 building energy efficiency standards, which is enforced through the building permit process. The measure will include both mandatory measures and prescriptive requirements.

Mandatory measures may include luminaire shielding requirements, and lighting controls (pre-curfew and curfew) for each of the environmental zones.

Prescriptive requirement will set maximum lighting power density limits, possibly for each of the environmental zones.

Regulatory Approaches

Lighting Power Density	The proposed measure may place prescriptive limits on the amount of power that can be used (Watts per square foot) of lighted uncovered parking lots.

Lighting Controls	The proposed measure may require photocell, programmable time clock or yearly astronomical controls to turn lighting off during daylight hours. Other controls may be required to extinguish some or all lighting in specific areas during curfew.
Equipment Specifications	Shielded luminaires may be required as a mandatory measure for certain areas, possibly dependent on environmental zones.
Illuminance Levels	Illuminance levels will be considered as a potential regulatory approach.

Considerations for Proposed Lighting Technologies

The lighting equipment and technologies needed to comply with the proposed requirement are already available in the market from multiple manufacturers. The typical product most widely used for parking lot lighting is an unshielded or partially shielded luminaire complying to an IESNA non-cutoff, semi-cutoff or cutoff designation. In some applications, IESNA or other recommendations may be used to discourage these products in favor of fully shielded luminaires meeting an IESNA full cut-off designation.

The equipment used for parking lot lighting requires maintenance, as does all lighting equipment. Typically high intensity discharge (HID) lighting sources are used which have a life between about 10,000 and 20,000 hours. The calendar time for lamp life (number of years) will depend on the pattern of operation. Lighting controls during pre-curfew and curfew hours may be used to reduce the operating hours thus reducing energy usage and maintenance.

Performance Verification

Performance verification is required for any lighting controls and luminaire shielding requirements. Designated lighting controls require calibration to insure that the lighting equipment is only energized between dusk and curfew or dawn, and that some security lighting is only illuminated during designated hours. Luminaire shielding types and installation compliance may need submission to appropriate authority for approval.

Technical Feasibility

Lighting equipment required is currently readily available from the majority of luminaire manufacturers. There are no technical feasibility issues.

Cost Effectiveness

The initial costs are projected to be equal or less than current practice. Energy operating costs will likely be lower so the proposed measure is projected to result in lighting designs that are cost effective. A life cycle cost analysis will be needed to verify cost effectiveness. Outdoor lighting controls may be required in areas where they can be justified by estimating the initial cost of the control, then determining how many hours must be reduced in order for the control to be cost effective.

Maximum lighting power densities may be established and demonstrated for each environmental zone, as appropriate, through the development of lighting models using IESNA and/or ETAL procedures. These models will include assumptions on task(s) performance with appropriate illumination levels and uniformity ratios. Limits on disability glare and discomfort glare may also be assumed for each model.

Since changes in adaptation levels affect the amount of light required for task performance (described in Background Information on ETAL, below), luminaires with the least amount of high angle light similar to IESNA full-cutoff designation may be determined to be most effective.

Compliance Documentation

The requirements may depend on a designation of environmental zones, which are not yet defined in California. This measure could incorporate the zones as part of the model standard if Commission analysis demonstrates that they would improve the standard.

The compliance process might include calculating the area of the lighted parking lot to multiply by the lighting power density for the designated environmental zone. Compliance forms could be developed for these calculations, including a checklist of control requirements and luminaire IESNA distribution types.

Bibliography and Other Research

EPRI Lighting Research Office, IESNA/LRO proceedings on Outdoor Lighting; February 25-27, 2002 (to be published)

Illuminating Engineering Society of North America, recommended practice RP-33-99 “Lighting for Exterior Environments”, New York, NY, 1999

Illuminating Engineering Society of North America, recommended practice RP-20-98 “Lighting for Parking Facilities”, New York, NY, 1998

Illuminating Engineering Society of North America, technical memorandum TM-11-00 “Light Trespass Research, Results and Recommendations”, New York, NY, 2000

Illuminating Engineering Society of North America, recommended practice RP-28-98 “Lighting and the Visual Environment for Senior Living”, New York, NY, 1998

Illuminating Engineering Society of North America, *Lighting Handbook,* Ninth Edition, 2000

American Society of Heating and Refrigerating Engineers, ASHRAE/IESNA 90.1-1999, Atlanta, Georgia, 1999

Measure 3 – Building Grounds Lighting (CEC)

Proposer

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Researcher
Nancy Clanton, PE, IALD, President
Clanton & Associates, Inc.
4699 Nautilus Court South, Suite 102
Boulder, CO 80301

Description

We propose to develop building grounds lighting power density limits to include in the Title 24 building energy efficiency standards. These will apply to exterior lighting not attached to the buildings or other structures such as canopies. Building grounds lighting includes lighting for landscape, pedestrian walkways, patios and other area lighting. For this proposed measure it does not include lighting associated with parking areas, building entrances and exits, retail sales, signs, facades and canopies. In addition this proposed measure does not address Recreational lighting. The Commission plans to determine the most appropriate method for computing building grounds area to include in lighting power allowance calculations.

Depending on the final analysis of the Energy Commission, the maximum lighting power densities may vary according to one of four environmental zones defined below in Background Information on Outdoor Lighting Environmental Zones and Curfew. The maximum lighting levels per zone will be established according to recommendations from Illuminating Engineering Society of North America (IESNA). These may be based on the “Evaluation of Task Adaptation Luminance” (ETAL) procedure. Refer to" Background Information on Evaluation of Task Adaptation Luminance" below.

The Commission will consider the need for lighting controls such as photocells and astronomical time clocks. Lighting controls may be required to turn off some or all lighting during curfew hours. Motion sensors may also be required to turn off or reduce lighting power (bi-level lighting control) during curfews hours or when the lights are not needed.

Benefits

Energy savings and peak demand reduction are major benefits of the proposed building grounds lighting standard. Other benefits may include reduced light trespass and pollution. The proposed standard will not affect safety and security, since reduced glare will increase visibility.

Environmental Impact

The proposed measure will have no negative environmental impact. The proposed measure will have only positive impacts including reducing light pollution and light trespass.

Enforcement Mechanism

The proposed measure will be implemented as part of the Title 24 building energy efficiency standards, which is enforced through the building permit process. The measure will include both mandatory measures and prescriptive requirements.

Mandatory measures may include luminaire shielding requirements, and lighting controls (pre-curfew and curfew), possibly for each of the environmental zones.

Prescriptive requirement will set maximum lighting power density limits, possibly for each of the environmental zones.

Regulatory Approaches

Lighting Power Density	The proposed measure may place prescriptive limits on the amount of power that can be used (Watts per square foot) for lighted site area.
Lighting Controls	The proposed measure may require photocell, programmable time clock or yearly astronomical controls to turn lighting off during daylight hours. Other controls may be required to extinguish some or all lighting in specific areas when lighting is not appropriate.
Equipment Specifications	Shielded luminaires may be required as a mandatory measure for certain areas, possibly dependent on environmental zones.

Considerations for Proposed Lighting Technologies

The lighting equipment and technologies needed to comply with the proposed requirement are already available in the market from multiple manufacturers. The standard product most widely used for landscape lighting is typically an unshielded or partially shielded luminaire. The standard product most widely used for site lighting is typically an unshielded or partially shielded luminaire complying to an IESNA non-cutoff, semi-cutoff or cutoff designation. In some applications IESNA or other recommendations may be used to discourage these products in favor of fully shielded luminaires meeting an IESNA full cut-off designation.

The equipment used for building grounds lighting requires maintenance, as does all lighting equipment. Typically high intensity discharge (HID), fluorescents or tungsten halogen lighting sources are used which have a life between about 2,000 and 20,000 hours. The calendar time for lamp life (number of years) will depend on the pattern of operation. Lighting controls during pre-curfew and curfew hours may be used to reduce the operating hours thus reducing energy usage and maintenance.

Performance Verification

Performance verification is required for the lighting controls and luminaire shielding requirements. Designated lighting controls require calibration to insure that the lighting equipment is only energized between dusk and curfew or dawn, and turned off during when lighting is not appropriate. Luminaire shielding types and installation compliance may need to be submitted to the appropriate authority for approval.

Technical Feasibility

Lighting equipment required is currently readily available from the majority of luminaire manufacturers. There are no technical feasibility issues.

Cost Effectiveness

The initial costs are projected to be equal or less than current practice. Energy operating costs will likely be lower so the proposed measure is projected to result in lighting designs that are cost effective. A life cycle cost analysis will be needed to verify cost effectiveness. Outdoor lighting controls may be required in areas where they can be justified by estimating the initial cost of the control, then determining how many hours must be reduced in order for the control to be cost effective.

Maximum lighting power densities may be established and demonstrated for each environmental zone, as appropriate, through the development of lighting models using IESNA and/or ETAL procedures. These models will include assumptions on task(s) performance with appropriate illumination levels and uniformity ratios. Limits on disability glare and discomfort glare may also be assumed for each model.

Since changes in adaptation levels affect the amount of light required for task performance (described in Background Information on ETAL, below), luminaires with the least amount of high angle light similar to IESNA full-cutoff designation may be determined to be most effective.

Compliance Documentation

The requirements may depend on a designation of environmental zones, which are not yet defined in California. This measure could incorporate the zones if Commission analysis demonstrates that they would improve the standard.

The compliance process might include calculating the area of the lighted site to multiply by the lighting power density for the designated environmental zone. Compliance forms could be developed for these calculations, including a checklist of control requirements and luminaire IESNA distribution types.

Bibliography and Other Research

EPRI Lighting Research Office, IESNA/LRO proceedings on Outdoor Lighting; February 25-27, 2002 (to be published)

Illuminating Engineering Society of North America, recommended practice RP-33-99 “Lighting for Exterior Environments”, New York, NY, 1999

Illuminating Engineering Society of North America, technical memorandum TM-11-00 “Light Trespass Research, Results and Recommendations”, New York, NY, 2000

Illuminating Engineering Society of North America, recommended practice RP-28-98 “Lighting and the Visual Environment for Senior Living”, New York, NY, 1998

Illuminating Engineering Society of North America, *Lighting Handbook,* Ninth Edition, 2000

American Society of Heating and Refrigerating Engineers, ASHRAE/IESNA 90.1-1999, Atlanta, Georgia, 1999

Measure 4 – Building Entrance and Exit Lighting (CEC)

Proposer

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Researcher
Lisa Heschong, Architect, LC
Partner
Heschong Mahone Group
11626 Fair Oaks Blvd, #302
Fair Oaks CA 95628

Description

Building entrance and exit doorway areas will be considered for prescriptive lighting power density limits and mandatory control measures included in the Title 24 building energy efficiency standards.

Depending on the final analysis of the Energy Commission, the maximum lighting power densities may vary according to one of four environmental zones defined below in Background Information on Outdoor Lighting Environmental Zones and Curfew. The maximum lighting levels per zone will be established according to recommendations from Illuminating Engineering Society of North America (IESNA). These may be based on the “Evaluation of Task Adaptation Luminance” (ETAL) procedure. Refer to" Background Information on Evaluation of Task Adaptation Luminance" below.

The Commission will consider the need for lighting controls such as photocells and astronomical time clocks. Lighting controls may be required to turn off some or all lighting during curfew hours. Motion sensors may also be required to turn off or reduce lighting power (bi-level lighting control) during curfews hours or when the lights are not needed.

This proposed measure applies only to un-covered entrance and exit areas for buildings. Entrances and exits that are covered by a canopy are described by another proposed measure.

Benefits

Energy savings and peak demand reduction are major benefits of the proposed standard.

Environmental Impact

The proposed measure will have no known negative environmental impact. The proposed measure will have only positive impacts including potential reductions in light pollution and light trespass.

Enforcement Mechanism

The proposed measure will be implemented as part of the Title 24 building energy efficiency standards both as mandatory measures (controls) and prescriptive requirements (limits on lighting power density). The building permit process enforces Title 24.

The measure will include both mandatory measures and prescriptive requirements. Mandatory measures may include luminaire shielding requirements, and lighting controls (daytime, pre-curfew and curfew) for each of the environmental zones.

Regulatory Approaches

Lighting Power Density	Prescriptive requirements may include limits placed on the amount of power that can be used per square foot of horizontal site area.

Lighting Controls	Mandatory measures may include photocell, programmable time clock or yearly astronomical controls to extinguish lighting during times it would be inappropriate.
Equipment Specifications	Cutoff and luminaire performance criteria may be additional mandatory measures for certain areas.

Considerations for Proposed Lighting Technologies

The lighting equipment and technologies needed to comply with the proposed requirements are already available in the market from multiple manufacturers.

Performance Verification

Performance verification is required for the lighting controls and luminaire shielding requirements. Required lighting controls need calibration to insure that the lighting equipment is only energized when appropriate. Luminaire shielding types and installation compliance may need to be submitted to the appropriate authority for approval.

Technical Feasibility

Lighting equipment required is currently readily available from the majority of equipment manufacturers. There are no technical feasibility issues.

Cost Effectiveness

The initial costs are projected to be equal or less than current practice. Energy operating costs will likely be lower so the proposed measure is projected to result in lighting designs that are cost effective. A life cycle cost analysis will be needed to verify cost effectiveness. Outdoor lighting controls may be required in areas where they can be justified by estimating the initial cost of the control, then determining how many hours must be reduced in order for the control to be cost effective.

Maximum lighting power densities may be established and demonstrated for each environmental zone, as appropriate, through the development of lighting models using IESNA and/or ETAL procedures. These models will include assumptions on task(s) performance with appropriate illumination levels and uniformity ratios. Limits on disability glare and discomfort glare may also be assumed for each model.

Since changes in adaptation levels affect the amount of light required for task performance (described in Background Information on ETAL, below), luminaires with the least amount of high angle light similar to IESNA full-cutoff designation may be determined to be most effective.

Compliance Documentation

The requirements may depend on a designation of environmental zones, which are not yet defined in California. This measure could incorporate the zones as part of the proposed measure if Commission analysis demonstrates that they would improve the standard.

The compliance process might include calculating the area of the lighted entrance or exit to multiply by the lighting power density for the designated environmental zone. Compliance forms could be developed for these calculations, including a checklist of control requirements and luminaire IESNA distribution types.

The compliance process would be similar to that used for interior lighting applications. Research by the Commission would establish a method to determine entrance or exit area. This area would be multiplied by the lighting power allowance for the designated environmental zone to determine allowed lighting power.

Compliance forms may be developed for doing these calculations, and made available to jurisdictions selecting this standard. These forms may also include a checklist of control performance requirements.

Bibliography and Other Research

EPRI Lighting Research Office, IESNA/LRO proceedings on Outdoor Lighting; February 25-27, 2002 (to be published)

Illuminating Engineering Society of North America, recommended practice RP-33-99 “Lighting for Exterior Environments”, New York, NY, 1999

Illuminating Engineering Society of North America, technical memorandum TM-11-00 “Light Trespass Research, Results and Recommendations”, New York, NY, 2000

Illuminating Engineering Society of North America, recommended practice RP-28-98 “Lighting and the Visual Environment for Senior Living”, New York, NY, 1998

Illuminating Engineering Society of North America, *Lighting Handbook,* Ninth Edition, 2000

American Society of Heating and Refrigerating Engineers, ASHRAE/IESNA 90.1-1999, Atlanta, Georgia, 1999

John Hogan and others; experiences implementing outdoor lighting codes

Measure 5 – Building Facades Lighting (CEC)

Proposer

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Researcher
Nancy Clanton, PE, IALD, President
Clanton & Associates, Inc.
4699 Nautilus Court South, Suite 102
Boulder, CO 80301

Description

We propose to develop building facade lighting power density limits to include in the Title 24 building energy efficiency standards. The Commission plans to determine the most appropriate method for computing façade area to include in lighting power allowance calculations.

Depending on the final analysis of the Energy Commission, the maximum lighting power densities may vary according to one of four environmental zones defined below in Background Information on Outdoor Lighting Environmental Zones and Curfew. The maximum lighting levels per zone will be established according to recommendations from Illuminating Engineering Society of North America (IESNA). These may be based on the “Evaluation of Task Adaptation Luminance” (ETAL) procedure. Refer to" Background Information on Evaluation of Task Adaptation Luminance" below.

The Commission will consider the need for lighting controls such as photocell and astronomical time clocks. Lighting controls may be required to turn off some or all lighting during curfew hours. Motion sensors may also be required to turn off or reduce lighting power (bi-level lighting control) during curfews hours or when the lights are not needed.

Benefits

Energy savings and peak demand reduction are major benefits of the proposed building facade standard. Other benefits include reduced light trespass and pollution. The proposed standard will not affect safety and security, since reduced glare will increase visibility.

Environmental Impact

The proposed measure has no negative environmental impacts. The proposed measure will have only positive impacts including reducing light pollution and light trespass.

Enforcement Mechanism

The proposed measure will be implemented as part of the Title 24 building energy efficiency standards, which is enforced through the building permit process. The measure will include both mandatory measures and prescriptive requirements.

Mandatory measures may include luminaire shielding requirements, and lighting controls (pre-curfew and curfew), possibly for each of the environmental zones.

Prescriptive requirement will set maximum lighting power density limits, possibly for each of the environmental zones.

Regulatory Approaches

Lighting Power Density	The proposed measure may place prescriptive limits on the amount of power that can be used (Watts per square foot) for lighted building facades.

Lighting Controls	The proposed measure may require photocell, programmable time clock or yearly astronomical controls to turn lighting off during daylight hours. Other controls may be required to extinguish some or all lighting in specific areas during curfew.
Equipment Specifications	Shielded luminaires may be required as a mandatory measure for certain areas, possibly dependent on environmental zones.

Considerations for Proposed Lighting Technologies

The lighting equipment and technologies needed to comply with the proposed requirement are already available in the market from multiple manufacturers. The typical product most widely used for building façade lighting is an unshielded or partially shielded luminaire complying to an IESNA non-cutoff, semi-cutoff or cutoff designation. In some applications, IESNA or other recommendations may be used to discourage these products in favor of fully shielded luminaires meeting an IESNA full cut-off designation.

The equipment used for building facade lighting requires maintenance, as does all lighting equipment. Typically high intensity discharge (HID) lighting sources, fluorescent and tungsten halogen lamps are used which have a life between about 2,000 and 20,000 hours. The calendar time for lamp life (number of years) will depend on the pattern of operation. Lighting controls during pre-curfew and curfew hours may be used to reduce the operating hours thus reducing energy usage and maintenance.

Performance Verification

Performance verification is required for any lighting controls and luminaire shielding requirements. Designated lighting controls require calibration to insure that the lighting equipment is only energized between dusk and curfew or dawn, and all building façade lighting is turned off during designated hours. Luminaire shielding types and installation compliance may need submission to appropriate authority for approval.

Technical Feasibility

Lighting equipment required is currently readily available from the majority of luminaire manufacturers. There are no technical feasibility issues.

Cost Effectiveness

The initial costs are projected to be equal or less than current practice. Energy operating costs will likely be lower so the proposed measure is projected to result in lighting designs that are cost effective. A life cycle cost analysis will be needed to verify cost effectiveness. Outdoor lighting controls may be required in areas where they can be justified by estimating the initial cost of the control, then determining how many hours must be reduced in order for the control to be cost effective.

Maximum lighting power densities may be established and demonstrated for each environmental zone, as appropriate, through the development of lighting models using IESNA and/or ETAL procedures. These models will include assumptions on task(s) performance with appropriate illumination levels and uniformity ratios. Limits on disability glare and discomfort glare may also be assumed for each model.

Since changes in adaptation levels affect the amount of light required for task performance (described in Background Information on ETAL, below), luminaires with the least amount of high angle light similar to IESNA full-cutoff designation may be determined to be most effective.

Compliance Documentation

The requirements may depend on a designation of environmental zones, which are not yet defined in California. This measure could incorporate the zones as part of the model standard if Commission analysis demonstrates that they would improve the standard.

The compliance process might include calculating the area of the lighted facade to multiply by the lighting power density for the designated environmental zone. Compliance forms could be developed for these calculations, including a checklist of control requirements and luminaire IESNA distribution types.

Bibliography and Other Research

EPRI Lighting Research Office, IESNA/LRO proceedings on Outdoor Lighting; February 25-27, 2002 (to be published)

Illuminating Engineering Society of North America, recommended practice RP-33-99 “Lighting for Exterior Environments”, New York, NY, 1999

Illuminating Engineering Society of North America, technical memorandum TM-11-00 “Light Trespass Research, Results and Recommendations”, New York, NY, 2000

Illuminating Engineering Society of North America, recommended practice RP-28-98 “Lighting and the Visual Environment for Senior Living”, New York, NY, 1998

Illuminating Engineering Society of North America, *Lighting Handbook,* Ninth Edition, 2000

American Society of Heating and Refrigerating Engineers, ASHRAE/IESNA 90.1-1999, Atlanta, Georgia, 1999

Measure 6 – Lighting Under Exterior Canopies (CEC)

Proposer

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Researcher
James R. Benya, PE
Benya Lighting Design
1880 Willamette Falls Drive Suite 220
West Linn, OR 97068

Description

Power density limits for lighting under exterior canopies will be developed and included in the Title 24 building energy efficiency standards. These will apply to all types of canopied areas, including but not limited to, service station canopies, car ports, canopies over entries to buildings, covered outdoor sales areas, stadium stand shelters and other covered areas under permanent or semi-permanent overhead structures. The Commission plans to determine the most appropriate method for computing canopy area to include in lighting power allowance calculations.

Depending on the final analysis of the Energy Commission, the maximum lighting power densities may vary according to one of four environmental zones defined below in Background Information on Outdoor Lighting Environmental Zones and Curfew. The maximum lighting levels per zone will be established according to recommendations from Illuminating Engineering Society of North America (IESNA). These may be based on the “Evaluation of Task Adaptation Luminance” (ETAL) procedure. Refer to" Background Information on Evaluation of Task Adaptation Luminance" below.

It is anticipated that certain types of lighting may be exempted from power limits, and these exemptions may vary depending on the environmental zone. Title 24 Section 146 – Prescriptive Requirements For Lighting, Subsection a-5, excludes some types of lighting from power allowances. Examples are lighting for theme parks, special effects lighting for dance floors and lighting equipment that is for sale. These exclusions would be considered a part of this measure. Curfew limits, however, may still apply.

The Commission will consider the need for lighting controls such as photocell and astronomical time clocks. Lighting controls may be required to turn off some or all lighting during curfew hours. Motion sensors may also be required to turn off or reduce lighting power (bi-level lighting control) during curfews hours or when the lights are not needed.

Benefits

Energy savings and peak demand reductions are major benefits of the proposed outdoor canopy standard. Other benefits include reduced light trespass and pollution. The proposed standard will also serve to improve roadway safety, since reduced glare will increase visibility.

Environmental Impact

The proposed measure will have no negative environmental impact. The proposed measure will have only positive impacts including reducing energy use, light pollution and light trespass.

Enforcement Mechanism

The proposed measure will be implemented as part of the Title 24 building energy efficiency standards, which is enforced through the building permit process. The measure will include both mandatory measures and prescriptive requirements. This measure increases the scope of the Standard in accordance with SB-5X.

Mandatory measures may include luminaire shielding requirements, and lighting controls (pre-curfew and curfew) for each of the environmental zones.

Prescriptive requirements may set maximum lighting power density limits for each of the environmental zones.

Regulatory Approaches

Power density will be the primary regulatory means. Maximum allowable power density values will be determined by modeling in a manner similar to interior lighting standards models. Efficacy values consistent with current standards will be used (e.g. "high efficacy sources" as defined for interior lighting). Varying the standards by environmental zones may be permitted to accommodate the range of ambient light and exterior lighting needs occurring throughout California. These models will include assumptions on task(s) performance with appropriate illumination levels and uniformity ratios. Limits on disability glare and discomfort glare will also be assumed for each model. Equipment specifications will be a secondary regulatory means. Cutoff angles and source types may be included in the mandatory provisions as a means of controlling *prima fascia* waste.

Considerations for Proposed Lighting Technologies

The lighting equipment and technologies needed to comply with the proposed requirement are readily available in the market from multiple manufacturers. The standard products most widely used for canopy lighting are partially shielded canopy lights, and lighting levels are often in excess of those needed for the purpose. When the proposed measure is implemented these products and practices may be discouraged in favor of shielded luminaires and appropriate light levels.

The equipment used for canopy lighting requires maintenance, as does all lighting equipment. Typically, fluorescent and high intensity discharge (HID) lighting sources are used which have a life between about 10,000 and 20,000 hours. The calendar time for lamp life (number of years) will depend on the pattern of operation. Lighting controls that extinguish unnecessary light during daytime, pre-curfew and curfew hours may be used to reduce the operating hours thus reducing energy use and maintenance.

Performance Verification

Performance verification is required for the lighting controls and luminaire shielding requirements. Required lighting controls need calibration to insure that the lighting equipment is only energized between dusk and curfew or dawn, and selected security lighting is only energized during curfew hours. Luminaire shielding types and installation compliance may need submission to appropriate authority for approval.

Technical Feasibility

Lighting equipment required is currently readily available from the majority of luminaire manufacturers. There are no technical feasibility issues.

Cost Effectiveness

The initial costs are projected to be equal or less than current practice. Energy operating costs will likely be lower so the proposed measure is projected to result in lighting designs that are cost effective. A life cycle cost analysis will be needed to verify cost effectiveness. Outdoor lighting controls may be required in areas where they can be justified by estimating the initial cost of the control, then determining how many hours must be reduced in order for the control to be cost effective.

Maximum lighting power densities may be established and demonstrated for each environmental zone, as appropriate, through the development of lighting models using IESNA and/or ETAL procedures. These models will include assumptions on task(s) performance with appropriate illumination levels and uniformity ratios. Limits on disability glare and discomfort glare may also be assumed for each model.

Since changes in adaptation levels affect the amount of light required for task performance (described in Background Information on ETAL, below), luminaires with the least amount of high angle light similar to IESNA full-cutoff designation may be determined to be most effective.

Compliance Documentation

The requirements may depend on a designation of environmental zones, which are not yet defined in California. This measure could incorporate the zones as part of the model standard if Commission analysis demonstrates that they would improve the standard.

The compliance process might include calculating the area of the lighted canopies to multiply by the lighting power density for the designated environmental zone. Compliance forms could be developed for these calculations, including a checklist of control requirements and luminaire IESNA distribution types with a reference to the plans and/or specifications where compliance can be verified by the plans examiner.

Bibliography and Other Research

EPRI Lighting Research Office, IESNA/LRO proceedings on Outdoor Lighting; February 25-27, 2002 (to be published)

Illuminating Engineering Society of North America, recommended practice RP-33-99 “Lighting for Exterior Environments”, New York, NY, 1999

Illuminating Engineering Society of North America, technical memorandum TM-11-00 “Light Trespass Research, Results and Recommendations”, New York, NY, 2000

Illuminating Engineering Society of North America, recommended practice RP-28-98 “Lighting and the Visual Environment for Senior Living”, New York, NY, 1998

Illuminating Engineering Society of North America, Lighting Handbook, Chapter 17—Retail Lighting, Ninth Edition, 2000

American Society of Heating and Refrigerating Engineers, ASHRAE/IESNA 90.1-1999, Atlanta, Georgia, 1999

Measure 7 – Outdoor Sales Lighting (CEC)

Proposer

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Researcher
James R. Benya, PE
Benya Lighting Design
1880 Willamette Falls Drive Suite 220
West Linn, OR 97068

Description

Power density limits for outdoor sales lighting will be developed and included in the Title 24 building energy efficiency standards. These will apply to all types of uncovered outdoor sales areas and lots, including but not limited to, vehicle sales, home sales and garden sales. The Commission plans to determine the most appropriate method for computing sales area to include in lighting power allowance calculations.

Depending on the final analysis of the Energy Commission, the maximum lighting power densities may vary according to one of four environmental zones defined below in Background Information on Outdoor Lighting Environmental Zones and Curfew. The maximum lighting levels per zone will be established according to recommendations from Illuminating Engineering Society of North America (IESNA). These may be based on the “Evaluation of Task Adaptation Luminance” (ETAL) procedure. Refer to" Background Information on Evaluation of Task Adaptation Luminance" below.

The Commission will consider the need for lighting controls such as photocell and astronomical time clocks. Lighting controls may be required to turn off some or all lighting during curfew hours. Motion sensors may also be required to turn off or reduce lighting power (bi-level lighting control) during curfews hours or when the lights are not needed.

Benefits

Energy savings and peak demand reductions are major benefits of the proposed outdoor sales standard. Other benefits include reduced light trespass and pollution. The proposed standard will also serve to improve roadway safety, since reduced glare from sales lighting will increase visibility.

Environmental Impact

The proposed measure will have no negative environmental impact. The proposed measure will have only positive impacts including reducing energy use, light pollution and light trespass.

Enforcement Mechanism

The proposed measure will be implemented as part of the Title 24 building energy efficiency standards, which is enforced through the building permit process. The measure will include both mandatory measures and prescriptive requirements. This measure increases the scope of the Standard in accordance with SB-5X.

Mandatory measures may include luminaire shielding requirements, and lighting controls (daytime, pre-curfew and curfew) for each of the environmental zones.

Prescriptive requirement will set maximum lighting power density limits, possibly for each of the environmental zones.

Regulatory Approaches

Lighting power density will be the primary regulatory means. Maximum allowable power density values will be determined by modeling in a manner similar to interior lighting standards models.

Equipment specifications will be a secondary regulatory means. The proposed measure may require photocell, programmable time clock or yearly astronomical controls to turn lighting off during daylight hours. Other controls may be required to extinguish some or all lighting in specific areas during curfew. Cutoff angles and source types may be included in the mandatory provisions as a means of controlling waste.

Considerations for Proposed Lighting Technologies

The lighting equipment and technologies needed to comply with the proposed requirement are readily available in the market from multiple manufacturers. The standard product most widely used for sales lighting is typically an unshielded or partially shielded floodlight, and lighting levels are in excess of those needed for the purpose. IESNA or other recommendations may discourage these products in favor of fully shielded luminaires meeting an IESNA full cut-off designation.

The equipment used for outdoor sales lighting requires maintenance as does all lighting equipment. Typically high intensity discharge (HID) lighting sources are used which have a life between about 10,000 and 20,000 hours. The calendar time for lamp life (number of years) will depend on the pattern of operation. Lighting controls during daytime, pre-curfew and curfew hours may be used to reduce the operating hours thus reducing energy use and maintenance.

Performance Verification

Performance verification is required for the lighting controls. Required lighting controls need calibration to insure that the lighting equipment is only energized between dusk and curfew or dawn, and selected security lighting is only energized during curfew hours. Luminaire and installation compliance may need submission to appropriate authority for approval.

Technical Feasibility

Lighting equipment required is currently readily available from the majority of luminaire manufacturers. There are no technical feasibility issues.

Cost Effectiveness

The initial costs are projected to be equal or less than current practice. Energy operating costs will likely be lower so the proposed measure is projected to result in lighting designs that are cost effective. A life cycle cost analysis will be needed to verify cost effectiveness. Outdoor lighting controls may be required in areas where they can be justified by estimating the initial cost of the control, then determining how many hours must be reduced in order for the control to be cost effective.

Maximum lighting power densities may be established and demonstrated for each environmental zone, as appropriate, through the development of lighting models using IESNA and/or ETAL procedures. These models will include assumptions on task(s) performance with appropriate illumination levels and uniformity ratios. Limits on disability glare and discomfort glare may also be assumed for each model.

Since changes in adaptation levels affect the amount of light required for task performance (described in Background Information on ETAL, below), luminaires with the least amount of high angle light similar to IESNA full-cutoff designation may be determined to be most effective.

Compliance Documentation

The requirements may depend on a designation of environmental zones, which are not yet defined in California. This measure could incorporate the zones as part of the model standard if Commission analysis demonstrates that they would improve the standard.

Otherwise, the compliance process will be similar to that used for interior lighting applications. The process might include calculating the area of the lighted sales area to multiply by the lighting power density for the designated environmental zone. Compliance forms could be developed for doing these calculations. These forms will be published as part of the non-residential and residential manuals.

Bibliography and Other Research

EPRI Lighting Research Office, IESNA/LRO proceedings on Outdoor Lighting; February 25-27, 2002 (to be published)

Illuminating Engineering Society of North America, recommended practice RP-33-99 “Lighting for Exterior Environments”, New York, NY, 1999

Illuminating Engineering Society of North America, recommended practice RP-8-00 “American National Standard Practice for Roadway Lighting”, New York, NY, 2000

Illuminating Engineering Society of North America, technical memorandum TM-11-00 “Light Trespass Research, Results and Recommendations”, New York, NY, 2000

Illuminating Engineering Society of North America, recommended practice RP-28-98 “Lighting and the Visual Environment for Senior Living”, New York, NY, 1998

Illuminating Engineering Society of North America, *Lighting Handbook,* Ninth Edition, page 17-11, 2000

American Society of Heating and Refrigerating Engineers, ASHRAE/IESNA 90.1-1999, Atlanta, Georgia, 1999

Additional Research and Comment

The IESNA Outdoor Lighting Criteria Forum identified “Merchandising Lighting” and “Security Lighting” as accepted lighting components. These will undoubtedly have a significant Environmental Zone relationship. For example, the basic lighting requirements currently contained in the IESNA Handbook for auto sales lighting are relatively low light levels, e.g. 10-20 footcandles for the front row of autos in a highly competitive market and 5-10 for a secondary market. It is common practice to employ 2-5 times these amounts. IESNA work is expected to identify to what extent additional lighting is “merchandising” and/or “security” and how much is recommended, by Environmental Zone.

We expect to use California Energy Commission, Public Interest Energy Research (PIER) research data as an interim value set for adjusting basic visibility criteria.

Measure 8 – Billboard and Outdoor Signage Lighting (CEC)

Proposer Name

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Researcher
Lisa Heschong, Architect, LC
Partner
Heschong Mahone Group
11626 Fair Oaks Blvd, #302
Fair Oaks CA 95628

Description:

Billboard and sign lighting power density limits will be developed for a model standard that can be adopted by local jurisdictions or any other state or local regulations governing the installation of signs or billboards. The Commission will also consider including these lighting power limits in the Title 24 Building Energy Efficiency Standard. These will apply to all types of permanently installed outdoor signs and billboards, with the exception of publicly owned street or directional signs or temporary signs in place for 60 days or less.

The lighting power densities will be applied to a representative sign area computed by a method to be determined by The Commission.

Depending on the final analysis of the Energy Commission, the maximum lighting power densities may vary according to one of four environmental zones defined below in Background Information on Outdoor Lighting Environmental Zones and Curfew. The maximum lighting levels per zone will be established according to recommendations from Illuminating Engineering Society of North America (IESNA). These may be based on the “Evaluation of Task Adaptation Luminance” (ETAL) procedure. Refer to" Background Information on Evaluation of Task Adaptation Luminance" below.

The Commission will consider the need for lighting controls such as photocell and astronomical time clocks. Lighting controls may be required to turn off some or all lighting during curfew hours. Motion sensors may also be required to turn off or reduce lighting power (bi-level lighting control) during curfews hours or when the lights are not needed.

Benefits

Energy savings and peak demand reduction are major benefits of the proposed signage standard. Other benefits could include reduced light trespass and light pollution, and reduced glare for passers-by.

Environmental Impact

The proposed measure will have no known negative environmental impact. The proposed measure will have only positive impacts including reducing light pollution and light trespass.

Enforcement Mechanism

The proposed measure will also establish a model standard that can be adopted by local jurisdictions. In this way it will be enforced through zoning codes and/or local design review mechanisms for any sign or billboard subject to those jurisdictions. If The Commission decides to include the proposed measure as part of the Title 24 building energy efficiency standards, the building permit process would provide enforcement for that aspect. Signs and billboards that fall within the jurisdiction of transportation or access rights of way could be reviewed by the agency responsible for the right of way, such as CALTRANS or a port authority.

The measure may include both mandatory measures and prescriptive requirements. Mandatory measures may include luminaire shielding requirements, and lighting controls (daytime, pre-curfew and curfew) for each of the environmental zones.

Regulatory Approaches

The following regulatory approaches apply both for a model standard and for the measure if incorporated into Title 24.

Lighting Power Density	The model standard may place prescriptive limits on the amount of power that can be used (Watts per square foot) of lighted outdoor signs and billboards
Lighting Controls	The model standard may require photocells, programmable time clock or yearly astronomical controls to turn lighting off during daylight hours. Other controls may be required to extinguish some or all lighting in specific areas during curfew.
Equipment Specifications	Shielded luminaires may be required by the model standard for certain areas, possibly dependent on environmental zones.

Considerations for Proposed Lighting Technologies

The lighting equipment and technologies needed to comply with the proposed requirement are technically feasible and could be manufactured. Research will be required to determine the number of applicable products that are already available in the market. The requirements might initiate changes in market share for outdoor luminaires. Any new product requirements are most likely to be on the optics and photometrics of signage luminaires rather than changes in electronics or lamp hardware.

Controls are available which meet all the performance requirements anticipated. Automatic, programmable, and remote-controlled lighting controls are readily available. Dimming and multi-lamp switching options for bi-level illumination levels are also becoming more feasible, especially for fluorescent sources.

Cut off and shielded luminaires are readily available. Development of products with new optical systems will likely increase luminaire placement flexibility.

Many of the anticipated requirements can be met simply with billboard or sign design along with luminaire positioning.

Performance Verification

Performance verification is required for the lighting controls and luminaire shielding requirements. Required lighting controls require calibration to insure that the lighting equipment is only energized between dusk and curfew, and selected security lighting is only energized during curfew hours. Luminaire shielding types and installation compliance may need to be submitted.

Technical Feasibility

Lighting equipment that will comply with these proposed requirements is currently commercially available from a range of equipment manufacturers. New equipment that may provide luminaire placement flexibility could be developed.

Cost Effectiveness

The initial costs are projected to be equal or less than current practice. Energy operating costs will likely be lower so the proposed measure is projected to result in lighting designs that are cost effective. A life cycle cost analysis will be needed to verify cost effectiveness. Outdoor lighting controls may be required in areas where they can be justified by estimating the initial cost of the control, then determining how many hours must be reduced in order for the control to be cost effective.

Maximum lighting power densities may be established and demonstrated for each environmental zone, as appropriate, through the development of lighting models using IESNA and/or ETAL procedures. These models will include assumptions on task(s) performance with appropriate illumination levels and uniformity ratios. Limits on disability glare and discomfort glare may also be assumed for each model.

Compliance Documentation

The requirements may depend on a designation of environmental zones, which are not yet defined in California. This measure could incorporate the zones as part of the model standard if Commission analysis demonstrates that they would improve the standard.

The compliance process would be similar to that used for interior lighting applications. Research for The Commission would establish a method to determine signage area. This area would be multiplied by the lighting power allowance for the designated environmental zone to determine allowed lighting power.

Compliance forms may be developed for doing these calculations, and made available to jurisdictions selecting this standard. These forms may also include a checklist of control performance requirements.

Bibliography and Other Research

EPRI Lighting Research Office, IESNA/LRO proceedings on Outdoor Lighting; February 25-27, 2002 (to be published)

Illuminating Engineering Society of North America, recommended practice RP-33-99 “Lighting for Exterior Environments”, New York, NY, 1999

Illuminating Engineering Society of North America, recommended practice RP-8-00 “American National Standard Practice for Roadway Lighting”, New York, NY, 2000

Illuminating Engineering Society of North America, technical memorandum TM-11-00 “Light Trespass Research, Results and Recommendations”, New York, NY, 2000

American Society of Heating and Refrigerating Engineers, ASHRAE/IESNA 90.1-1999, Atlanta, Georgia, 1999

The Highway Beautification Act of 1965 controls outdoor advertising along interstate roads at the federal level. States can further regulate outdoor advertising through the "Bonus Act". The Bonus Act provided an incentive to states to control outdoor advertising within 660 feet of the Interstate highway system.

California's "bonus" program is the Outdoor Advertising Act. It prohibits advertising displays whose illumination impairs the vision of travelers on adjacent highways. Illumination must comply to the values set forth in Section 21466.5 of the Vehicle Code.

Measure 9 – Public Right of Way Lighting (CEC)

Proposer

California Energy Commission
1516 Ninth Street
Sacramento, CA 95814

Researcher
Nancy Clanton, PE, IALD, President
Clanton & Associates, Inc.
4699 Nautilus Court South, Suite 102
Boulder, CO 80301

Description

We will develop a model standard for Public Right of Way lighting power density limits. This standard will be limited to roadways, streets, walkways and bikeways within the public right of way. Depending on the final analysis of the Energy Commission, the maximum lighting power densities may vary according to one of four environmental zones defined below in Background Information on Outdoor Lighting Environmental Zones and Curfew. The maximum lighting levels per zone will be established according to recommendations from Illuminating Engineering Society of North America (IESNA). These may be based on the “Evaluation of Task Adaptation Luminance” (ETAL) procedure. Refer to" Background Information on Evaluation of Task Adaptation Luminance" below.

The Commission will consider the need for lighting controls such as photocells and astronomical time clocks. Lighting controls may be required to turn off some or all lighting during curfew hours. Motion sensors may also be required to turn off or reduce lighting power (bi-level lighting control) on walkways and bikeways during curfews hours or when the lights are not needed.

Benefits

Energy savings and peak demand reduction are major benefits of the proposed public right of way lighting standard. Other benefits include reduced light trespass and pollution. The proposed standard will reduce glare and increase visibility.

Environmental Impact

The proposed measure will have no negative environmental impact. The proposed measure will have only positive impacts including reducing light pollution, light trespass and energy use.

Enforcement Mechanism

This measure will develop a model standard that California State, its counties and communities can incorporate into their lighting standards. Mandatory measures may include luminaire shielding requirements, and lighting controls (pre-curfew and curfew) for each of the environmental zones.

Prescriptive requirements may set maximum lighting power density limits for each of the environmental zones. The lighting power densities will be applied to roadways, streets, walkways, and bikepaths.

Regulatory Approaches

Lighting Power Density	The model standard may place prescriptive limits on the amount of power that can be used (Watts per square foot) of lighted streets, roadways, walkways and bikepaths.
Lighting Controls	The model standard may require photocells, programmable time clock or yearly astronomical controls to turn lighting off during daylight hours. Other controls may be required to extinguish some or all lighting in specific areas during curfew.

Equipment Specifications Shielded luminaires may be required by the model standard for certain areas, possibly dependent on environmental zones.

Considerations for Proposed Lighting Technologies

The lighting equipment and technologies needed to comply with the proposed requirement are already available in the market from multiple manufacturers. The standard product most widely used for public right of way lighting is typically an unshielded or partially shielded luminaire complying to an IESNA non-cutoff, semi-cutoff or cutoff designation. In some applications, IESNA or other recommendations may be used to discourage these products in favor of fully shielded luminaires meeting an IESNA full cut-off designation.

The equipment used for public right of way lighting requires maintenance, as does all lighting equipment. Typically used high intensity discharge (HID) lighting sources have a life between about 10,000 and 20,000 hours. The calendar time for lamp life (number of years) will depend on the pattern of operation. Lighting controls during pre-curfew and curfew hours may be used to reduce the operating hours thus reducing energy use and maintenance.

Performance Verification

Performance verification is needed for the lighting controls and luminaire shielding requirements. Designated lighting controls require calibration to insure that the lighting equipment is only energized between dusk and curfew or dawn, and selected street, roadway, walkway and bikepath lighting is only energized during designated hours. Luminaire shielding types and installation compliance may need submission to appropriate authority for approval.

Technical Feasibility

Lighting equipment required is currently readily available from many luminaire manufacturers. There are no technical feasibility issues.

Cost Effectiveness

The initial costs are projected to be equal or less than current practice. Energy operating costs will likely be lower so the proposed measure is projected to result in lighting designs that are cost effective. A life cycle cost analysis will be needed to verify cost effectiveness. Outdoor lighting controls may be required in areas where they can be justified by estimating the initial cost of the control, then determining how many hours must be reduced in order for the control to be cost effective.

Maximum lighting power densities may be established and demonstrated for each environmental zone, as appropriate, through the development of lighting models using IESNA and/or ETAL procedures. These models will include assumptions on task(s) performance with appropriate illumination levels and uniformity ratios. Limits on disability glare and discomfort glare may also be assumed for each model.

Since changes in adaptation levels affect the amount of light required for task performance (described in Background Information on ETAL, below), luminaires with the least amount of high angle light similar to IESNA full-cutoff designation may be determined to be most effective.

Compliance Documentation

The requirements may depend on a designation of environmental zones, which are not yet defined in California. This measure could incorporate the zones as part of the model standard if Commission analysis demonstrates that they would improve the standard.

The compliance process might include calculating the area of the lighted street, roadway, walkway or bikepath to multiply by the lighting power density for the designated environmental zone. Compliance forms could be developed for these calculations, including a checklist of control requirements and luminaire IESNA distribution types.

Bibliography and Other Research

EPRI Lighting Research Office, IESNA/LRO proceedings on Outdoor Lighting; February 25-27, 2002 (to be published)

Illuminating Engineering Society of North America, recommended practice RP-33-99 “Lighting for Exterior Environments”, New York, NY, 1999

Illuminating Engineering Society of North America, recommended practice RP-8-00 “American National Standard Practice for Roadway Lighting”, New York, NY, 2000

Illuminating Engineering Society of North America, technical memorandum TM-11-00 “Light Trespass Research, Results and Recommendations”, New York, NY, 2000

Illuminating Engineering Society of North America, recommended practice RP-28-98 “Lighting and the Visual Environment for Senior Living”, New York, NY, 1998

California Department of Transportation Traffic Manual Chapter 9 sections 9-06 through 9-13, [http://www.dot.ca.gov/hq/traffops/signtech/signdel/chp9/chap9.htm]

California Department of Transportation, "Standard Plans", July, 1999 (Revised October 26, 2000), [http://www.dot.ca.gov/hq/esc/oe/project_plans/HTM/stdplns-met-new99.htm]

American Society of Heating and Refrigerating Engineers, ASHRAE/IESNA 90.1-1999, Atlanta, Georgia, 1999

Environmental Zones and Curfew

Environmental Zone Description

Lighting criteria and design depend to a substantial extent on the ambient light and setting of the project. Likewise, tolerance for light pollution and light trespass declines as the setting of the project is removed from urban and suburban environments. In order to address these issues correctly, lighting power density and other regulations need to be based on environmental zones, which provide for reduced light in low ambient light settings. Future IESNA and international design standards will use the same four environmental zone system, as defined by the Commission Internationale de L'Eclairage (CIE) and Illuminating Engineering Society of North America (IESNA).

Environmental Zones
E1: Areas with intrinsically dark landscapes. Examples are national parks, areas of outstanding natural beauty, or residential areas where inhabitants have expressed a strong desire for strict limitation of light trespass.
E2: Areas of low ambient brightness. These may be suburban and rural residential areas. Roadways may be lighted to typical residential standards.
E3: Areas of medium ambient brightness. These will generally be urban residential areas. Roadway lighting will normally be to traffic route standards.
E4: Areas of high ambient brightness. Normally this category will include dense urban areas with mixed residential and commercial use with a high level of nighttime activity.

Curfew

Curfew is a time established for a lower light level. Environmental zones may suggest multiple time periods with different illumination requirements. For example, periods might include a daytime period from sunrise to sunset when essentially all outdoor lighting is not appropriate; a dawn and evening pre-curfew period when standard outdoor lighting regulations apply; and a curfew period, such as 11:00 P.M. to an hour before sunrise, when stricter regulations apply. These periods could be specified as part of the definitions of the environmental zone, or modified by the local jurisdiction according to local needs and preferences. Thus, regulation for each environmental zone might identify appropriate illumination limits for the three types of periods, but allow the specific hourly designations for each period to vary according to local preferences.

Implementing Environmental Zones

Environmental zones are not yet legally defined in California, but are defined by CIE and IESNA. The Commission will determine the best way to implement outdoor lighting environmental zones. One way may be to tie zones E1-E4 to established local zoning ordinances, defining which lighting zone correlates to each existing local zone.

Another possible method would establish a set of defaults where national parks, state parks, nature preserves, the rural coastal zone and public wilderness areas are designated as intrinsically dark areas, environmental zone E1. All other areas default to a low ambient level environmental zone E2 designation, unless a city or county or the responsible state or federal agency specifically zones a defined local area as an intrinsically dark area E1, a medium ambient level E3, or high ambient level E4 environmental zone. Thus, a state park would be considered an E1 zone, with the exception of local areas designated by the Park Service or other authority with jurisdiction as having a higher zone. Likewise, county land would be considered E2 unless the county had specifically designated an area otherwise, as E1, E3, or E4. A second alternative the Commission will consider is essentially identical, but to place statistical metropolitan areas larger than 40,000 into a default environmental zone E3; as above, local governments could adjust this zone to their preference. A third alternative the Commission will consider are established planning zones to associate environmental zones. The Commission will develop clear guidelines that local authorities can follow when they consider adopting environmental zone 4 in lieu of default environmental zones.

Benefits

The environmental zone approach allows an outdoor light regulation to designate the use of light appropriate to the use and settlement patterns of a local area. Overly high limits do not have to be set for all conditions, and likewise, overly restrictive regulations do not have to apply to areas in brightly lit situations. With appropriate regulation for each zone, energy savings can be optimized.

Other benefits include reduced light trespass and light pollution by zone, specific protection of wildlife from excessive light at night in designated natural areas, and public review and participation in the process of setting the environmental area zoning definitions. The environmental zone approach allows for variation in standards by local preferences, within the maximum and minimum conditions allowed overall.

Technical Feasibility

Use of environmental zones requires definitions of geographic areas that can be specially identified by property owners. It must be easy to determine which lighting environmental zone applies to any parcel of land. Local zoning ordinances are a common method of identifying all restrictions that a local jurisdiction places on a given piece of property, and thus a mechanism for identifying outdoor lighting environmental zones.

The state defaults must apply to areas that already have legal status at the state level. This may include the rural California Coastal Zone, state parks, wildlife refuges, and others to be identified. The Energy Commission will interface with other state agencies to identify appropriate state level definitions of properties for inclusion in the E1 category.

The regulation may have to set rules of precedence to be followed if a property is administered by more than one jurisdiction, for example by a city, a regional planning board, and CALTRANS.

Bibliography and Other Research

EPRI Lighting Research Office, IESNA/LRO proceedings on Outdoor Lighting; February 25-27, 2002 (to be published)

Illuminating Engineering Society of North America, recommended practice RP-33-99 “Lighting for Exterior Environments”, New York, NY, 1999

Illuminating Engineering Society of North America, recommended practice RP-8-00 “American National Standard Practice for Roadway Lighting”, New York, NY, 2000

Illuminating Engineering Society of North America, technical memorandum TM-11-00 “Light Trespass Research, Results and Recommendations”, New York, NY, 2000

EPRI, TR-114914, "Light Trespass Research", Palo Alto, CA, 2000

New Buildings Institute, "Advanced Lighting Guidelines 2001", White Salmon, WA, 2001

Moore, Chadwick A., "Visual Estimations of dark Sky Brightness", [http://www.georgewright.org/184moore.pdf], The George Wright Society, Inc., Hancock, MI, 2001

Public Resources Code, Division 20, California Coastal Act, (January 2002)

Evaluation of Task Adaptation Luminance (ETAL)

Evaluation of Task Adaptation Luminance (ETAL) is a procedure that determines the required luminance for a specific task at a specific visual adaptation level (ambient illumination level). This procedure will identify how much light is needed for outdoor task(s) performance under different lighting conditions. Under extremely low ambient lighting levels, ETAL will identify what tasks can be performed and what tasks cannot be performed. When ambient lighting conditions increase more difficult tasks can be performed but the amount of light required to see a task also increases. The advantage of the ETAL method is determining lighting level requirements for a variety of tasks under a variety of ambient lighting levels.

How is ETALCalculated?

The brightness and darkness relationship of a task produces spatial frequencies (the rate of change of luminance across the field of view). Computer filters are then inserted to lower the spatial frequencies that represent adaptation levels. This information is assessed for visual performance at typical adaptation levels. Visual acuity is based on size of object, object contrast and speed one has to "see" the task. As lighting levels drop, the visual acuity drops. Visual acuity relationships are already written into our standards. Missing from the standards, however, are the effects that our adaptation level has on visual acuity. ETAL can simulate visual acuity for different tasks, under different lighting levels, for a multitude of adaptation levels.

The first step for an ETAL determination is to identify visual tasks. Technical committees of the Illuminating Engineering Society of North America (IESNA) will develop these visual tasks for typical outdoor areas including roadways, parking lots, walkways, bikeways, building entries, and outdoor retail areas.

Once the tasks have been identified, a digital daytime image of an outdoor scene will be analyzed for spatial frequencies. Low spatial frequencies will be associated with large tasks and gradual variations such as identifying the edge between grass and asphalt. High spatial frequencies will distinguish small tasks and sharp crisp lines such as white striping on dark asphalt. These spatial frequencies will be adjusted for different ambient lighting conditions to determine how much light one needs to perform a task. The spatial frequency of a digital image is, in simple terms, the physical distance between recurring features of high and low contrast. This is similar to the wavelength of a periodically occurring stripe (wave) that contrasts with its background. National Aeronautics and Space Administration (NASA) and others have commonly used computerized spatial frequency image analysis for many years.

An example task is a gas station, where the scene image shows the gas pumps under a canopy along with the driveway, surrounding sidewalks and street. The tasks may include reading the pump instructions, filling the gas tank, checking oil, reading the charge slip, and walking around the property, including on the sidewalk.

The ambient lighting levels or adaptation levels are directly related to the amount of light the eye is adapted to in the scene. If the canopy were lighted to high light levels, the visual adaptation levels would be high, requiring more light to perform the tasks. As adaptation levels lower, the amount of light required would be less.

This method also responds to the effect of disability glare. As more direct glare is present, the adaptation level increases and image contrast decreases, thus requiring more light to perform a task.

How Are ETAL Results Used?

Since the results will produce task luminance levels for different adaptation levels, acceptable adaptation levels can be indicated in a community ordinance and/or directly related to the IESNA environmental zone classifications (E1 through E4). In an E1 category the small amount of disability glare allows a lower adaptation level. An E4 category may indicate a higher adaptation level where more brightness is acceptable.

When adaptation levels and environmental zones are established, then corresponding lighting power densities can be applied to each zone.

Conclusion

The advantage of the ETAL method over existing consensus illuminance standards is correlating visibility to adaptation levels. This allows lighting power densities to correspond to task performance in different environmental zones. Since disability glare is accounted for in the ETAL method, lighting equipment that provides the least amount of glare may provide the most effective lighting. As environmental zones lower, lighting power densities lower, thus saving energy without compromising task performance.

Bibliography and Other Research

Bichao, I.C, C.D. Yager, and A.L. Lewis, "Computer simulation of roadway lighting evaluation: a preliminary report", *Vision in Vehicles-V*, A.G. Gale et al, eds., Elsevier Science BV, Amsterdam, 1996.

Illuminating Engineering Society of North America, recommended practice RP-28-98 “Lighting and the Visual Environment for Senior Living”, New York, NY, 1998

Appendix A – Existing Outdoor Lighting Standards

Excerpts from the California Building Energy Efficiency Standards

§130 (c) Exterior Building Lighting. All permanently installed exterior luminaires attached to or powered by the electrical service in buildings that contain conditioned space(s), and employing lamps rated over 100 watts shall either: have a source efficacy, determined by dividing the rated initial lamp lumens by the rated lamp watts, of at least 60 lumens per watt; or be controlled by a motion sensor.

EXCEPTION 1 to Section 130 (c): Lighting required by a health or life safety statute, ordinance, or regulation, including but not limited to, emergency lighting.

EXCEPTION 2 to Section 130 (c): Lighting that is integral to advertising signage.

EXCEPTION 3 to Section 130 (c): Lighting used in or around swimming pools, water features, or other locations subject to Article 680 of the 1998 California Electrical Code

EXCEPTION 4 to Section 130 (c): Searchlights and lighting for use in theme parks.

EXCEPTION 5 to Section 130 (c): Outdoor theatrical equipment, provided it is for temporary or periodic use and is not for continuous use.

§131 (f) Exterior Lighting. All permanently installed exterior lighting attached to or powered by the electrical service in buildings that contain conditioned space(s) shall be controlled by a directional photocell or astronomical time switch that automatically turns off the exterior lighting when daylight is available.

EXCEPTION to Section 131 (f): Lighting in parking garages, tunnels, and large covered areas that require illumination during daylight hours.

ALTERNATIVE TO §150 (k)2. A high-efficacy luminaire need not be installed in a bathroom if:

…

B. All luminaries permanently mounted to the residence providing outdoor lighting shall be installed with the following characteristics:

(1) Luminaires with lamps with 40 lumens per watt or greater; or

(2) Luminaires with lamps with an efficacy of less than 40 watts lumens per watt shall be equipped with a motion sensor.

Excerpts from ASHRAE/IESNA Standard 90.1-1989 User's Manual

Exterior Lighting Controls (§6.4.2.8)

With the exception of exterior lighting designed for 24-hour operation, all exterior lighting shall be controlled by photocells, time switches or a combination of the two. Time switches must be seven-day, astronomical (or have some means of seasonal compensation). There must also be a power backup to enable accurate time keeping through a minimum four-hour power loss.

Traditionally, exterior lights have been controlled by electro-mechanical clocks with mechanical trippers which toggle circuit switches. These devices typically are equipped with a manual override. Many of these traditional devices do not have either seasonal correction or four-hour backup and will *not* meet the requirements of §6.4.2.8. The following devices will meet the requirements:

- Seven-day electrically-driven, mechanical clock with trippers, astronomical dial and four-hour spring-wound storage

- Seven-day or calendar year, electronic programmable time switch with astronomic correction and battery backup
- Either of the above with a photocell (in lieu of astronomical correction)

Of these, the last is best since it automatically and continuously compensates for changes in the seasons, and has the redundancy of the timeclock control, which will operate if the photosensor fails.

Exterior Lighting Power (§6.4.1)

Standard 90.1 separates the maximum power requirements for exterior and interior lighting systems. The exterior lighting power allowance (ELPA) is a basic requirement, which must be met in all methods of compliance including the energy cost budget method.

Trade-offs are not permitted between the exterior lighting systems and other building systems, including interior lighting, with any method of compliance. For multibuilding facilities, the exterior lighting power allowance (ELPA) applies to the entire site and trade-offs are permitted between exterior lighting systems on the site.

What is Covered

Most exterior lighting is covered by the Standard including all permanent lighting fixtures intended for lighting the building and its grounds.

Building-Mounted Exterior Lighting. All lighting mounted on the building, less specific exceptions as noted below, is governed. This generally means all lanterns, soffit lights, floodlights, step lights, wall packs and any decorative lighting such as neon outlining, low-voltage light strips and ornamental pendants and globes.

Grounds, Roads, Parking Lots and Other Exterior Lighting. All lighting on the building site, less specific exceptions as noted below, is governed. This generally includes pole-mounted lighting, landscape lighting, bollards, step lights, wall packs and all other lighting for the roads, walks, parking lots, gardens, trees and other portions of the site. Note that lighting not powered by the building electrical system, such as municipal street lights, is exempt.

Open-air parking lots, rooftop parking and carports are included in the exterior lighting requirements. Covered parking garages are part of the interior lighting requirements and are *not* included with the exterior lighting.

Exempt Exterior Lighting

Section 6 does not regulate lighting over which the designer has little choice or control, as described below. Lighting for safety, security or commercial needs is also exempt. The following are specific lighting applications exempt by the Standard.

Emergency Lights, Exit Signs and Mandatory Safety or Security Lights. If a code or ordinance requires lighting for safety or security, then it is generally exempt. It is *not* exempt if it is used as part of non-mandated lighting as well. An emergency egress light is exempt if it is normally off and switched through life-safety controls; however, if the light also serves as a general light source, it is *not* exempt. Typically exempt lighting also includes exit signs, security lights (such as for automatic teller machines) and other lights required by security or safety officials.

Sign Lights. Both self-contained and external illumination for signs are exempt.

Exterior Lighting. Outdoor lighting for a wide variety of special situations is exempt, including:

- Outdoor Manufacturing, Commercial Greenhouses and Processing Facilities. This in general is meant to exempt outdoor commercial, agricultural and industrial work areas, ranging from nighttime farming activities to refineries.
- Outdoor Athletic Facilities. Lighting for outdoor sports of all kinds is exempt.
- Exterior Lighting for Public Monuments
- Lighting for Dwelling Units. Note that exterior lighting as well as interior lighting for dwelling units is exempt.

Definitions Used with Exterior Lighting Calculations

The allowance for some of these areas involves judgment. The following definitions are provided as a guide:

Exit. A door or group of doors to a building not ordinarily used as an entrance and primarily used as an emergency, nighttime or convenience exit.

Entrance (without canopy). A door or group of doors to a building ordinarily used by tenants or the public to enter the building for normal use or business, but having no ornamental or functional canopy or shelter.

Entrance (with canopy). A door or group of doors to a building with an exterior awning, soffit, canopy or ornamental or functional structure generally signifying a "main" or "proper" entrance to a building. A canopy does not have to be shelter; the major issue here is identification or marketing.

Public Exterior Areas. Public areas are intended to mean those used by the occasional and/or unfamiliar user of the building. For instance, parking and roads for hotels, airports, shopping centers, etc. are "public." Also public are the roads leading to a private building, such as an office building, plus the visitor parking and all walks leading into the main entry.

Private Exterior Areas. Private exterior areas are those whose users are frequent and/or familiar users of the facility. Typical situations include private parking lots and drives to them.

Exterior Lighting Power Allowance

To determine exterior lighting compliance the designer must calculate both the exterior connected lighting power (CLP) of the proposed design and the exterior lighting power allowance (ELPA). Compliance is achieved if the exterior CLP is less than or equal to the ELPA.

The exterior CLP is calculated by summing the exterior lighting power for all luminaires that are included in the scope of the exterior lighting requirements.

The ELPA is calculated by multiplying each lighted area (or length of door opening) by the appropriate exterior lighting power allowance from Table 6-1. This table is repeated as Table 6-B below.

There are three types of measurements used in determining ELPA:

- *Area of Horizontal Area Descriptions.* Typically flat or rolling area of grounds, driveways, lots, gardens or parks are measured from site plans. In general, measure and compute the area as if the site were flat. Sites with extreme topography can be allowed a larger area than the horizontal projection due to the actual area of the land's contours; however, unless a sophisticated and accurate method for determining surface area is used, then the "flat" condition must be assumed. In the case of canopies, the area of the canopy ceiling measured in the flat plane determines the area to be used. Even if the canopy is slanted or peaked inside, the measurement is actually of the ground beneath the canopy.
- *Linear Length of Door Openings.* This value is measured in plan view and includes the door opening only; sidelights and other portions of the door which do not open are not part of the linear length.
- *Area of Building Facades.* The intent is to provide a reasonable allowance to light the exterior of buildings for identification, aesthetic and marketability reasons. This area is the sum of all areas of the building exterior intended to be illuminated. Note that many of the surfaces are not in the vertical plane, such as soffits, overhangs, slants and other geometric shapes. Determining the area of these shapes will involve more complex calculations.

Table 6-C Exterior Lighting Unit Power Allowances

Area Description	Allowances
Exit (with or without canopy)	25 W/lin ft of door opening
Entrance (without canopy)	30 W/lin ft of door opening
Entrance (with canopy)	
High traffic (retail, hotel, airport, theater, etc.)	10 W/ft² of canopied area
Light traffic (hospital, office, school, etc.)	4 W/ft² of canopied area
Loading area	0.40 W/ft²
Loading door	20 W/lin ft of door opening
Building exterior surfaces/facades	0.25 W/ft² of surface area to be illuminated
Storage and non-manufacturing work areas	0.20 W/ft²
Other activity areas for casual use such as picnic grounds, gardens, parks and other landscaped areas	0.10 W/ft²
Private driveways/walkways	0.10 W/ft²
Public driveways/walkways	0.15 W/ft²
Private parking lots	0.12 W/ft²
Public parking lots	0.18 W/ft²
Parking garages[2]	0.20 W/ft²

Excerpts from ASHRAE/IESNA Standard 90.1-1999 User's Manual

General Information

Exterior lighting equipment has new efficacy requirements. The 1989 Standard contained exterior lighting power requirements for parking lots and building grounds. These requirements have been eliminated. Instead, the new Standard specifies a minimum efficacy (lumens/watt) for outdoor lighting. (Note that parking garages are included in interior lighting.)

Exterior and Interior Lighting Power Trade-Offs. The Standard contains separate requirements for exterior and interior lighting systems. Exterior and interior lighting must comply separately with their respective requirements. Trade-offs between the two are not allowed. Trade-offs are permitted, however, within interior lighting power and within some parts of exterior building lighting power.

Garages and Parking Areas. A covered garage is treated as interior space and is included as part of the interior adjusted lighting power. Open parking lots (including rooftop parking) are not covered by the exterior lighting requirements. However, § 9.2.6 requires an efficacy of at least 60 lumens per watt for open parking lots, which means that metal halide, high-pressure sodium, or efficient fluorescent sources must be used.

Exterior Lighting Control (§ 9.2.1.3)

All exterior lighting shall be automatically switched by photocells, time switches, or a combination of the two. If timers are used, they must be able to account for seasonal differences in the length of the day as it changes throughout the year. Although not required by the Standard, designers should choose timers that are equipped with power backup to allow accurate timekeeping during temporary power outages and to avoid having to reset the timer after such an outage.

Traditionally, exterior lights have been controlled by electro-mechanical clocks with mechanical trippers that toggle circuit switches. These devices typically are equipped with a manual override. Many of these traditional devices do not have seasonal correction. As such, they do not meet the requirements of § 9.2.1.3. The following devices will meet the requirements:

- Photocells
- Seven-day electrically driven mechanical clocks with trippers, astronomical dial, and four-hour spring-wound storage

[2] Parking garages are considered interior lighting under ASHRAE/IESNA Standard 90.1-1989.

- Seven-day or calendar-year electronic programmable time switches with astronomic correction and battery backup
- Either of the timers above, with a photocell in place of astronomical correction

Of all these devices, a photocell-time clock combination is the most effective, since its photocell automatically and continuously compensates for changes in the seasons. In addition, the redundancy of the time clock control allows for continued operation if the photocell fails.

Exterior Building Grounds Lighting (§ 9.2.6)

Parking lots, pedestrian walkways, gardens, and other landscaped areas associated with a building must have an efficient lighting system. The Standard requires that all exterior building grounds luminaires that operate at more than 100 watts have an efficacy greater than 60 lumens per watt. The efficacy requirement will eliminate the use of all incandescent and mercury vapor discharge sources greater than 100 watts in exterior building grounds luminaires. Full-size fluorescent, metal halide, high-pressure sodium, and most other high-intensity discharge (HID) lighting sources will have an efficacy greater than 60 lumens per watt. Small luminaires for walkways, exterior stairs, and other applications will typically be smaller than 100 watts and will be exempt from the requirement.

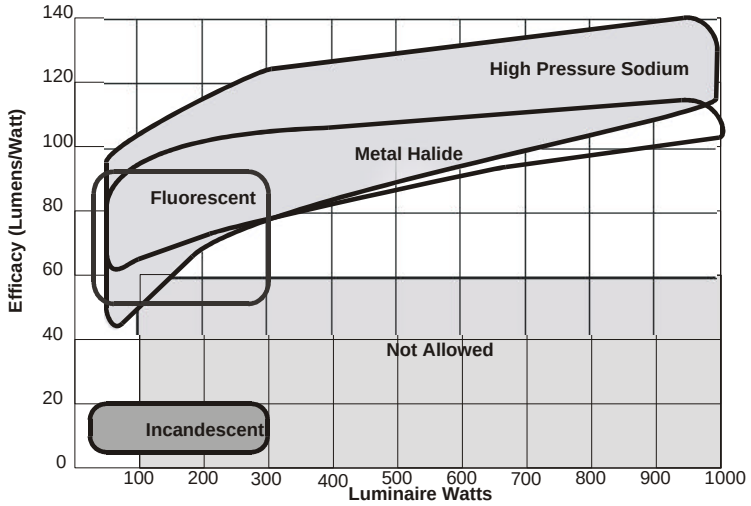

Figure 9-F– Exterior Grounds Lighting and Specific Technologies

Some exterior lighting applications are exempt from the requirement, including traffic signals, lighting within outdoor signs, and lighting used to illuminate public monuments or registered historic landmarks. There is an additional exemption to the lighting efficacy requirement when an occupancy sensor or motion sensor controls the lighting application.

Figure 9-F llustrates the efficacy requirements for exterior grounds lighting and shows the performance of typical luminaires. The horizontal axis shows typical luminaire size. The vertical axis shows source efficacy in lumens per watt. The boundaries of typical available products are shown for high-pressure sodium (HPS) luminaires, metal halide luminaires, incandescent luminaires, and compact fluorescent luminaires. This figure shows that typical high-pressure sodium and metal halide luminaires have an efficacy well above the required 60 lumens per watt. The only HPS luminaires that might not meet the requirement are those with small lamps (just over 100 W). Most fluorescent lamps also meet the requirement, especially those with electronic ballasts. Incandescent luminaires have an efficacy less than 20 lumens per watt; if they are larger than 100 W they would not meet the requirement.

Exterior Building Lighting Power (§ 9.3.2)

This requirement applies to all exterior grounds lighting with luminaires larger than 100 watts, including parking lots, pedestrian walkways, and landscape lighting. In addition, the Standard specifies the maximum exterior lighting power that can be used at building entrances and building exits and to illuminate building façades. The maximum power that can be used for these lighting applications is based on the area of the building façade or width of the entrances. These requirements are shown in Table 9-C, which is the same as Table 9.3.2 in the Standard.

The terms used in Table 9-D are clarified below:

Table 9-D – Lighting Power Limits for Building Exteriors
(This is Table 9.3.2 in the Standard)

Applications	*Power Limits*
Building entrance with canopy or free-standing canopy	3 W/ft^2 (32.4 W/m^2) of canopied area
Building entrance without canopy	33 W/lin ft (108.3 W/lin m) of door width
Building exit	20 W/lin ft (65.6 W/lin m) of door width
Building façades	0.25 W/ft^2 (2.7 W/m^2) of illuminated façade area

- *Building Entrance (with canopy)*. This lighting application refers to a door or group of doors to a building with an exterior awning, soffit, canopy, or other architectural means of sheltering people who are entering or exiting the building. The canopy or awning usually signifies a "main" or "proper" entrance to the building. A canopy does not have to be an actual shelter from the weather; the canopy's major function is often to identify the building's entrance or to advertise its owners or tenants. The lighting allowance for this type of entrance is 3 W/ft² (32.4 W/m²) of canopy area. The canopy area is the horizontal projection of the canopy (e.g., if the canopy slopes, the actual area may be greater than the horizontal projection).
- *Building Entrance (without canopy*). This lighting application refers to a door or group of doors to a building ordinarily used by tenants or the public to enter or exit the building. The distinction is that the entrance in this class does not have a canopy or shelter that extends from the building. The lighting power allowance is 33 W/lin ft (108.3 W/lin m) of entrance width.
- *Building Exit*. A building exit is usually an emergency exit and is not intended as the main entrance to the building. The allowance is 20 W/lin ft (65.6 W/lin m) of entrance width.
- *Building Façade*. Important buildings are often illuminated with exterior luminaires to highlight significant architectural features. The allowance is 0.25 W/ft² (2.7 W/m²) of building façade. The façade area used to determine the allowance is not the entire façade but rather the portion of the façade that needs to be illuminated.

Certain types of exterior lighting applications are specifically exempt when they are equipped with an independent control. These include the following:

a. Specialized signal, directional, and marker lighting associated with transportation are exempt. These include traffic signals, directional signs, and other similar luminaires.

b. Lighting applications are exempt when they are used to highlight public monuments and registered historic landmark structures or buildings. To qualify as historic, a monument or building must be specifically designated as historically significant by the adopting authority or listed in "The National Register of Historic Places." It may also be exempt if the U.S. Secretary of the Interior determines that the monument or building is eligible for listing in the Register.

c. All lighting within advertising signs is exempt. This includes pole-mounted or building-mounted signs as long as the lighting is integral to the sign. The exemption does not apply to building-mounted signs that are illuminated by luminaires positioned outside the sign and directed toward the sign.

Determining Exterior Building Lighting Power Compliance

Determining whether a building complies with the exterior building lighting power requirements is a two-step process. The first step is to calculate the exterior lighting power allowance (ELPA). The ELPA is calculated by multiplying each lighted area or width of door opening by the appropriate exterior lighting unit power allowance.

The second step is to calculate the exterior connected lighting power (CLP) of the proposed design. The exterior CLP is determined by totaling the exterior lighting power for all proposed exterior luminaires that are not exempt from the exterior lighting requirements. When determining input wattage for luminaires, it is important to include ballast losses for all fluorescent and HID sources. The input wattage tables in the Reference section of this chapter may be used to calculate CLP of specific light sources if luminaire manufacturer data are unavailable.

The project complies with the exterior building lighting requirement if the exterior CLP is less than or equal to the ELPA. Trade-offs are not allowed between the exterior lighting systems and any other building systems, including interior lighting systems. However, for multi-building facilities, the ELPA applies to the entire site. Thus, trade-offs are permitted between different *exterior* lighting systems on the site, provided the total exterior CLP does not exceed the total ELPA.